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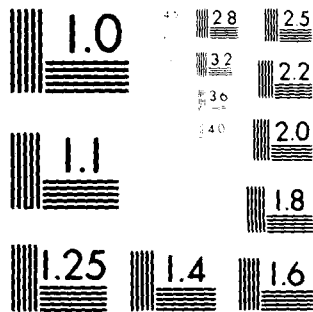
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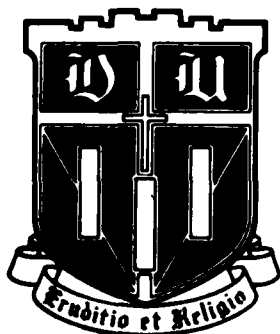
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TRANSLATION OF GAMBLING AND  
ASPIRATION LEVEL EFFECTS IN  
RISKY CHOICE BEHAVIOR

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(John W. Payne, Investigator)

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number) Two recent models of risky decision making developed by Fishburn [6] and by Kahneman and Tversky [4] have emphasized the importance of a target return or a reference point in determining preferences and choices among gambles. The target return and reference point concepts represent variations on an old idea in theories of decision making: level of aspiration. Additional evidence on the need to incorporate an aspiration level type		

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20. → of concept in the analysis of risky choice behavior is presented. In three experiments, the relationship of pairs of gambles to an assumed reference point was varied by adding or subtracting a constant amount of money from all outcomes. The results demonstrate that such translations of outcomes can result in the reversal of choice within pairs of gambles. The effect of such translations on choice depended on whether the size of the translation was sufficient to insure that one gamble in a pair had outcome values either all above or all below the reference point, while the other gamble had outcome values both above and below the reference point. The results are discussed in terms of the Fishburn and Kahneman-Tversky models, as well as other theories of risky decision making. A model of the effects of a reference point on risky choice behavior is presented.



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## 1. INTRODUCTION

The general concept of an aspiration level is an old idea in theories of decision making [25], [26]. Simon [26], for example, suggested that one way individuals simplify choice problems is to code an outcome as being one of two types: satisfactory if the outcome is above the aspiration level or unsatisfactory if it is below. A review of much of the early work on the aspiration level concept and its role in decision making is provided by McWhinney [18].

The potential significance of the aspiration level concept has been reemphasized recently in two new models of risky decision making developed by Fishburn [6] and Kahneman and Tversky [11]. In the Fishburn model, the risk of a gamble is associated with outcomes below a target return, while in the Kahneman-Tversky model outcomes are coded into gains and losses depending upon whether they are above or below a reference point. The concepts of target return and reference point used in these two models are special cases of an aspiration level, appropriately defined for alternatives with monetary consequences. For purposes of discussion in this paper, all three terms—target return, reference point, and aspiration level—are used interchangeably since all will refer to the pre-determined benchmark return used by a decision maker to translate monetary outcomes into gains and losses.

The purpose of the present paper is to provide additional empirical evidence on the need to incorporate a target return, reference point, or aspiration level concept in the analysis of risky choice behavior. The paper is organized as follows. First, the Fishburn and Kahneman-Tversky models are briefly discussed, along with results from previous surveys of managerial practice which have identified the importance of an aspiration level in the decision-making process of business executives. Next, the design of the

empirical study of aspiration level effects is discussed and related to the Fishburn and Kahneman-Tversky models. Results from three different experiments, one of which involved high-level managers as subjects, are then presented and the relationship of these results to several other models of decision-making under conditions of risk are discussed. A set of propositions that serve to summarize the empirical results, along with ideas contained in the literature, are then presented in order to highlight the impact of an aspiration level on risky choice behavior. The paper concludes with a brief discussion of the implications of the empirical evidence for model building in management science.

## 2. THE FISHBURN AND KAHNEMAN-TVERSKY MODELS

The Fishburn model, denoted the  $\alpha$ -t model, uses the concept of a target level of return to define the risk of an alternative. Formally, the risk of an alternative, denoted A, is measured as the following probability weighted function of returns below a target:

$$R(A) = \int_{-\infty}^t (t-x)^{\alpha} dF(x),$$

where  $F(x)$  is the probability of receiving a return not exceeding  $x$ ,  $t$  is the target return, and  $\alpha$  is a non-negative parameter used to measure the relative importance of the size of the deviations below target and the probability of failing to reach the target. Both  $\alpha$  and  $t$  are parameters that are unique to a decision maker. Fishburn argues that if the main concern of a decision maker is failure to achieve the target, without particular regard to the size of the deviation, then a value of  $\alpha$  in the range  $0 \leq \alpha < 1$  is appropriate. For this range of  $\alpha$  values, Fishburn demonstrates that the underlying utility function for the decision maker is convex for losses (consistent with risk seeking). On the other hand, Fishburn argues that a value of  $\alpha$  in the range  $\alpha > 1$  implies that the decision maker regards small deviations below target as being



relatively harmless when compared to large deviations. In this case, Fishburn shows that the decision maker has a utility function which is concave for losses (consistent with risk aversion).

In the  $\alpha$ -t model, the risk of an alternative is combined with its mean return to determine preference. Given any two alternatives A and B, having mean returns  $\mu(A)$  and  $\mu(B)$  respectively, A is preferred to B if and only if:  $\mu(A) \geq \mu(B)$  and  $R(A) \leq R(B)$  with at least one strict inequality holding. The general form of the  $\alpha$ -t model is a familiar one since it has the characteristics of a mean-risk dominance model. The important point for the present paper is the central role that the target level of return assumes in defining risk for the Fishburn model.

The Kahneman-Tversky model, called prospect theory, is proposed as an alternative to expected utility theory in its traditional form. Prospect theory views risky decision making as two-phase process. The first phase involves editing the given decision problem into a simpler representation in order to make the evaluation of gambles and choice easier for the decision maker. The second phase involves assigning an overall value to each edited gamble and the subsequent choice of the gamble with the greatest value. An important feature of prospect theory is the critical role that is attributed to an aspiration level in the analysis of risky decisions. A key operation in the editing phase is the coding by the decision maker of each of the outcomes of a gamble as being either a gain or a loss, with a gain or loss defined by the relationship of the outcome to a reference point or level of aspiration.<sup>1</sup> According to Kahneman and Tversky, a decision maker then responds to a gamble, in part, by assigning subjective values to the gains and losses associated it. The value function, which is the Kahneman-Tversky version of a utility function, is assumed to be concave for gains, convex for losses, and steeper for losses than for equivalent gains.<sup>2</sup> Kahneman and Tversky point

out that a consequence of their theory is that a change in the reference point may change the preference ordering among a set of gambles.

Kahneman and Tversky support their assumption that the value function is concave for gains and convex for losses, and hence support the need for a reference point, by showing that the preference ordering between gambles involving negative amounts of money is often the mirror image (reverse) of the preference ordering between gambles involving positive amounts of money. For example, [11, p. 268], the gamble which provides a chance to win \$3000 with probability .9 or to win nothing with probability .1, denoted  $(\$3000, .9)$  is usually chosen over the gamble  $(\$6000, .45)$ , a result which implies a concave value function. On the other hand, when these two gambles are reversed, the gamble  $(-\$6000, .45)$  is usually chosen over the gamble  $(-\$3000, .9)$ , a result which implies a convex value function. Kahneman and Tversky refer to this pattern of choices as the reflection effect.<sup>3</sup>

Additional evidence supporting a reference point or target level concept can be found in surveys of management practice. For example, Mao [16] asked executives in eight medium and large companies about the capital budgeting practices of their firms. One question concerned what the executives understood by the term "investment risk." A sample response one executive provided was [16, p. 343]:

"Risk is the prospect of not meeting the target rate of return. That is the risk, isn't it? If you are one hundred percent sure of making the target return, then it is a zero risk proposition."

A more recent, and more complete, survey of capital budgeting practices by Petty and Scott [11] also shows that the idea of a target return is widely used by managers. They sent a questionnaire to the chief financial officer of each firm listed in the May 1977 director of Fortune 500 firms and had a response rate of 35.3 percent. Respondents were asked to define a "risky

investment." The most common response was the probability of not achieving a target rate of return." Conrath [2], Libby and Fishburn [15] and Crum, Laughhunn and Payne [5] cite additional evidence on the use of a target or aspiration level concept in business decision making.

### 3. DESIGN OF THE STUDY

An experimental investigation of aspiration level effects on risky choice behavior can proceed in several ways. One procedure would be to try to change the aspiration level held by an individual through explicit instructions. For example, a decision maker might be told that he or she will be presented with a set of risky options to select from and that the target level of return on a project for his or her company is 18%. Another procedure would be to accept that there are individual differences in terms of aspiration levels, try to independently measure those differences, and then to determine if a correlation exists between the individual difference measures and different individual patterns of choice over a set of risky alternatives. This has been a popular approach of researchers working in the area of achievement motivation and selection of performance tasks, e.g., Atkinson and Raynor [1].

This study used a third procedure, based on a translation of outcomes, that is suggested by Kahneman and Tversky [11, p.287]. In this procedure the relationship between a set of risky alternatives and an aspiration level was manipulated through simple additive transformations of the alternatives. Consider the two three-outcome gambles shown in Figure 1. Gamble GI, denoted  $(a,p; b,q; c,1-p-q)$ , yields an outcome of value  $a$  with probability  $p$ , outcome  $b$  with probability  $q$ , and outcome  $c$  with probability  $1-p-q$ . The outcomes are ordered such that  $a > b > c$ . Gamble GII, denoted  $(x,r; y,s; z,1-r-s)$ , is similar in interpretation. Note that  $a > x$ ,  $b = y$ , and  $c < z$ . If we let  $b = y = \$0$  then

the two gambles represent "regular" prospects as defined by Kahneman and Tversky [11]. In addition, if we assume that for most decision makers a natural reference point is 0 (or  $t_3$ ) in Figure 1, then GI and GII each have one outcome above the level of aspiration and one below. The assumption that the point of no gain and no loss,

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Insert Figure 1 about here

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i.e., the status quo, serves as the aspiration level is often made [7], [11]. It is recognized, however, that the reference point may be above the status quo return or below it [7]. The probabilities associated with the outcomes of GI and GII are assumed to be different, but are specified so that the expected value of GI equals the expected value of GII. The condition of equal expected values was not necessary for the study, but was used to facilitate a subsequent comparison of experimental results with several theories of decision making.

The relationships between GI and GII and the assumed target  $t_3=0$  can be changed by the addition or subtraction of a constant  $k$  from all outcomes of GI and GII. Consider first a positive translation (addition of  $k$ ) where  $k > |z|$  but  $k < |c|$ . Under this translation of both gambles, GI would still have one outcome below  $t_3$ , while GII would have all outcomes above  $t_3$ . Another way of viewing the effect of this translation is that the level of aspiration is now at  $t_2$  in Figure 1.

Fishburn's model predicts that the translated gamble GII would be chosen over the translated gamble GI since both gambles continue to have equal expected values, whereas GII becomes riskless and GI remains risky for all values of  $\alpha$ .

The predicted choice between the translated version of GI and GII based on the Kahneman-Tversky model is not unambiguous for all decision makers since the overall value of each gamble depends upon the specific characteristics of the value function both above and below  $t_3$ , as well as the specific values of the translated outcomes and their probabilities. But the Kahneman-Tversky model does suggest the choice of GII over GI after the translation. Choice of GII over GI by a decision maker tends to occur because of the relative steepness of the value function for losses as compared to equivalent gains. A large negative value assigned to the outcome for GI that remains below  $t_3$  after the translation can cause the overall value of GI to decline below GII.<sup>4</sup> Another characteristic of the Kahneman-Tversky model that favors a choice of GII over GI after the positive translation is the fact that GII now provides a return above  $t_3$  with certainty. In this case, GII can be decomposed into a certain return and an incremental gamble. The Kahneman-Tversky model allows for the overweighting of the certain return component of GII, thereby also favoring a choice of GII over GI.

Now consider the effect of a negative translation of the outcomes for GI and GII by an amount  $-k$  where  $k$  is positive and  $k > x$  but  $k < a$ . After this translation of both gambles, GI would still have one outcome above the target  $t_3$ , while GII would now have all outcomes below the target. Another way of viewing the effect of this negative translation is that the target level has been raised to  $t_4$  in Figure 1.

The predicted choice of GI or GII based on Fishburn's model is not as definite under such a negative translation, since preferences depend upon the decision maker's risk attitude as measured by  $\alpha$  and the characteristics of the translated gambles. To the extent, however, that a decision maker is concerned primarily with the failure to achieve the target level of return, consistent with  $\alpha < 1$  and risk seeking for losses, then the choice of GI over

over GII is more likely. Estimates of  $\alpha$  obtained from business managers by Crum, et al. [5], using a procedure based on the Fishburn model, support the assumption that a large majority of individuals have  $\alpha$  values less than 1. Such individuals would exhibit a strong tendency to choose GI after the negative translation.

The Kahneman-Tversky model also does not make a definite prediction for the choice of either GI or GII, after the negative translation, that would hold for all decision makers. The overall value of GI and GII to any decision maker, and hence the gamble chosen, depends upon the specific characteristics of the value function, as well as the properties of the translated gambles. But given the general properties of the value function specified in their model, it is likely that a decision maker would choose GI. Choice of GI, which continues to have an outcome above  $t_3$  after the negative translation, is likely because GII now has all outcomes below the target, the region where a high degree of relative steepness occurs and where negative values are assigned by the value function. A further aspect of the translated gambles favoring the choice of GI is the fact that GII is now guaranteed to yield a return less than the target and can therefore be decomposed into a certain loss and an incremental gamble involving additional losses. The tendency of a decision maker to overweight certainty would, in this instance, lead to an overweighting of the certain loss that also has a large negative value to the decision maker. This would further reduce the overall value of GII relative to GI and favor the choice of GI.

For both the Fishburn and Kahneman-Tversky models, the implication is that a simple translation of outcomes by positive and negative amounts can result in a reversal of choice between GI and GII. The predominant pattern of choices is predicted to be a choice of GI under a negative translation ( $-k$ ) and for a reversal of choice to GII under a positive translation ( $k$ ).

It should be noted that the translations to be used in this study have been the subject of previous theoretical discussions of decision making under risk [10], [13], [14], [23]. In particular, Pfanzagl [23] has stated the principle that the relationship between a gamble and its certainty equivalent is invariant under the transformation that adds a constant to all gamble outcomes and to the certainty equivalent. Pfanzagl argues that this consistency principle has been tacitly assumed in many early treatments of expected utility theory. More recently, Holloway [10] suggests that the consistency principle is reasonable over ranges of outcomes and provides a simplification in the analysis of portfolios of gambles. It has also been argued that the interpretation of utility functions derived from empirical data is very problematic if the consistency principle does not hold [14].

Analysis of the Fishburn and Kahneman-Tversky models presented earlier, however, suggests that the consistency principle will be violated to the extent that reversals in choices occur whenever a translation involves crossing a level of aspiration. The following experiments examine the hypothesis that the choice from a pair of gambles will reverse as a function of such a translation of outcomes.

#### 4. EXPERIMENTAL RESULTS

##### Experiment 1

##### Method

The subjects were 30 undergraduate or graduate students at Duke University. The subjects were either paid at a fixed hourly rate for their participation in the experiment or were given credit toward a course requirement. The subjects were naive with respect to the task and stimuli.

The stimuli were pairs of three-outcome gambles. (See Table 1). Two initial sets of four "regular" gambles were constructed. The values of the probabilities associated with the gain and loss amounts were selected to range from .2 to .5 since this range is likely to be well-behaved and well understood by subjects [11], [12]. The values of the gain and loss amounts were selected to be in the range \$8 to \$86. This was selected to be one that would likely be substantial to the subjects without introducing any possibility of "great wealth" or "ruinous loss" amount having to be considered. Each gamble in the initial sets was constructed to have an expected value of \$0.

Four additional sets of gambles were then constructed by positive and negative translations of all outcomes for the initial gambles. The first set of four gambles was translated by an amount of \$30 and by an amount of -\$30. The second set of gambles was translated by an amount of \$26 and by an amount of -\$26. Pairs (A,B), (A,Y), (X,B) and (X,Y) are those in which one would expect to observe a shift in choice as a function of the translations.

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Insert Table 1 about here.

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Each subject was run individually. The subjects were told that they would be presented with pairs of gambles to choose from and that they should indicate which gamble in a pair they would prefer to play if they had to play one. They were also told to consider each pair of gambles independently. No time constraints were placed on subjects. They were instructed to work at their own pace and told they would have plenty of time to finish. Ten of the subjects were asked to give verbal protocols. The instructions were to "think aloud" continuously as they selected the gamble in each decision situation.



Each subject was presented with 36 pairs of gambles. The 36 pairs consisted of each gamble in a given set of four gambles paired with every other gamble in that set. In addition, there were four practice pairs presented at the beginning of each session. The stimuli were presented to each subject on the screen of a computer terminal (Perkin-Elmer, 1200), connected on-line to an HP-2000 computer. The presentation of pairs was in a different random order for each subject. Right-left positions of the gambles within a pair were counterbalanced across subjects and pairs.

### Results

The gamble in each of the pairs constructed from gamble sets 1 and 2 (see Table 1) that had the largest probability of winning was defined as GI. The other gamble was denoted GII. Table 2 presents the proportion of subjects choosing GI for each of the 36 pairs of gambles.

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Insert Table 2 about here

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It is clear from the proportions in Table 2 that positive and negative translations of the set of gambles led to reversals in choices. Aggregating across gamble sets 1 and 2, the mean proportion of choices of GI for the pairs of gambles (A,B), (A,Y), (X,B), and (X,Y) under a positive translation was .23. These pairs all involve GI with two outcomes above and one below the target and GII with all outcomes above the target. The choices were strongly in the direction of GII. On the other hand, when aggregated across both sets, the mean proportion of choices of GI for the same pairs of gambles under a negative translation was .67. A more direct test of the hypothesis that choice within a pair of gambles shifted as a function of the translations is

provided by counting the number of times the same gamble in a pair (either GI & GI or GII & GII) was chosen under a positive and negative translation and the number of times a shift in choice occurred, i.e., from GI to GII or from GII to GI. Table 3 presents the results of such a count across the 30 subjects and the eight critical pairs of gambles. The most common pattern of choice

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Insert Table 3 about here

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involved the predicted reversal: from GII for a positive translation to GI for a negative translation. A test of the equality of two correlated proportions, applied to the two cells that involved shifts in choice, showed a significant difference ( $\chi^2(1) = 78.0, p < .01$ ).

An analysis of the patterns of choice for each individual subject confirms this reversal. Twenty-five of the 30 subjects chose GII most often under the positive translation of pairs (A,B), (A,Y), (X,B) and (X,Y). Nineteen of the 30 subjects chose GI most often under a negative translation. Together, the group and individual analyses confirm shifts in choice, as a function of the translations, in the direction predicted by the Fishburn and Kahneman-Tversky models.

However, note in Table 2 that there was little indication of a choice reversal under a translation of outcomes for gamble pairs (A,X) and (B,Y). These pairs of gambles are ones for which the translations used were not sufficient to result in one gamble in a pair being moved totally above or totally below the assumed reference point of \$0.

Two other interesting patterns of choice can also be observed in Table 2. First, under the assumption that gamble B is less risky than gamble A and that gamble Y is less risky than gamble X, in the regular forms of the gambles

(for both sets 1 & 2), then a negative translation of gambles yielded greater risk seeking behavior. Such behavior is suggested by data presented in Williams [28] and predicted by Kahneman and Tversky [11]. A positive translation, on the other hand, leads to greater risk aversion. This is inconsistent with suggestions contained in Holloway [10] that the only likely effects of adding a constant to all outcomes are either no change in attitude toward risk or decreasing risk aversion. The rationale, according to Holloway, is that "...as the minimum payoff increases, an individual becomes less risk averse [10, p. 394]." Second, note that the aggregated choice proportions under the negative translations were generally less extreme than under the positive translations. This is consistent with the less clear preference prediction of the Fishburn model in this situation.

Finally, a third of the subjects in this experiment were asked to give verbal protocols. An examination of the patterns of choices for those 10 subjects as opposed to the other 20 subjects indicated that both groups of subjects responded similarly. In particular, the mean choice proportions of GI for the negative and positive translations were .30 and .68, and .19 and .67, for the protocol and nonprotocol subjects respectively.

#### Verbal Protocols

Verbal protocols can be used in a variety of ways in decision research [21]. The present paper used protocols simply to confirm and extend the interpretation of the choice data. A more formal analysis of the protocols will be presented in a separate paper. Complete protocols for each of the ten subjects when faced with the positive and negative translations of gamble pair A,B (sets 3 and 5 from Table 1, respectively) are provided in the Appendix. The protocols are broken up into short phrases corresponding to a naive assessment of a single task assertion or reference by the subject.

The protocols clearly support the view that the subjects were sensitive to whether a pair of gambles included one gamble with outcomes all above the target or one gamble with outcomes all below the target. In particular, note that for most of the subjects an early observation concerned whether a gamble in a pair offered an opportunity for only a gain or only a loss. As examples, consider the following excerpts from these protocols:

B1: In this case, gamble one has one negative outcome

B2: and gamble two has none.

or D1: Here I see I've got a 50% chance of winning choice two.

D2: No chance of winning choice one.

Finally, it should also be noted that even though subjects placed great importance on the probability of receiving a gain or a loss, they were sensitive to the amounts to be won or lost and did make tradeoff judgments. See, for example, the protocols for the first two subjects. Overall, the protocols appear consistent with the choice data and the interpretations of that data presented earlier.

### Experiment 2

In the previous experiment, all pairs of gambles were constructed so that the gamble in a pair with the greater probability of winning (GI) also had the greater variance. The second experiment used similar pairs of gambles and also pairs of gambles where the gamble in a pair with the greater probability of winning (GI) had the smaller variance. In addition, the format used to present the gambles was changed. For experiment 1, the gambles were presented in a matrix form on the screen of a computer terminal. Experiment 2 presented the options using a pie-diagram format.

## Method

The subjects were 42 paid undergraduates at Duke University. The subjects were recruited to participate in two studies: one involved questions about consumer behavior and the other involved a small number of risky choice questions. Both studies took place in a group setting including up to eight subjects.

Six pairs of gambles were constructed (see Table 4). Problem 1 and its positive and negative translations (problems 3 & 5) are similar to the pairs in experiment 1. Problem 2 and its translations (problems 4 & 6) have a slightly different pattern of relationships between the gambles in a pair, i.e., GI has a lower variance than GII.

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Insert Table 4 about here

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These six pairs of gambles were presented to the subjects in a booklet that contained a number of other choice problems. Each pair of gambles was on a separate page in the booklet. Each gamble was represented by a circle or pie diagram. The circles were divided into three sectors corresponding in size to the probabilities associated with the outcomes in each gamble. The amounts were displayed within the appropriate sector. The probabilities were displayed outside the appropriate sector. Payne [19] provides examples of the kinds of displays used. The order of the pairs of gambles was randomized within a booklet and across subjects. The position of a gamble on a page was counterbalanced across subjects. Each subject was instructed to indicate, on a response scale located underneath each pair of gambles, the choice of gamble and the strength of preference for the chosen gamble. The response scale ran from A to H, divided at a point halfway between D and E. The extremes

of the scale (A & H) were marked "strong" and scale positions adjacent to the center dividing line were marked "slight."

## Results

The numbers of subjects choosing each gamble in each pair are given in Table 4. The proportions of subjects choosing the gamble with all outcomes exceeding the target for the positive translation in problems 3 and 4 were .86 and .90, respectively. In contrast, under the negative translations in problems 5 and 6, the proportions of subjects choosing the same gamble were only .14 and .12. That is, the gamble that now involved all outcomes less than the target was chosen infrequently. On an individual level, 30 of the 42 subjects shifted choices between pairs 3 and 5, and 33 of the 42 subjects shifted choices between pairs 4 and 6. All the shifts in choice that occurred were in the predicted directions. These results are completely consistent with the results obtained in experiment 1. Note also, that the predicted and observed effects of the translation on choice proportions is the same in pairs 4 and 6 even though the variance relationship within the pairs (variance  $GI <$  variance  $GII$ ) is reversed from pairs 3 and 5 (variance  $GI >$  variance  $GII$ ).

In order to study the strength of preference exhibited between gambles in a pair, as contrasted to the direction of choice, the subjects actual responses (A through H) were transformed into the numerical values -7 to +7 in increments of 2, with negative values assigned to  $GI$ . The mean of the responses, taken without regard to sign, for the untranslated, positively translated, and negatively translated pairs were 3.69, 6.38, and 3.69, respectively. Clearly, stronger preferences were displayed for gamble pairs in which one gamble had all outcomes exceeding the target and the other gamble had a outcome below the target. These are precisely the pairs in which the Fishburn model predicts a dominance relationship.

Experiment 3

A criticism that is often expressed regarding decision research is the use of college students as subjects. Consequently, a third experiment was designed to examine the generality of choice reversals under a translation of outcomes by using business managers as subjects. In addition, the amounts of money involved in the risky options were increased by multiplying all outcomes by \$100,000. This adjustment in the size of the outcomes was designed to make the risky options more meaningful within the business environment of the managers.

Method

The subjects were 84 managers in several European firms from a broad cross-section of industry. The firms included a large bank, a chemical company, a major food chain, an airline, a consulting firm, a mining company, and several manufacturing firms. The managers occupied a variety of top level positions within these firms, with approximately half being in very senior positions (vice president or above).

The stimuli consisted of 12 of the pairs of gambles used in experiment 1. The 12 pairs were the ones from Table 1 generated by a complete pairing of the gambles listed in set 3 (six pairs) and a complete pairing of the gambles listed in set 5 (six pairs). The subjects, however, were told to consider the amounts as being measured in \$100,000 units.

The choice problems were presented to the subjects in a booklet, with each choice problem on a separate page. The order of the choice problems was randomized and the position of the alternatives on a page was counterbalanced. Each subject was asked to indicated choices as a manager. The instructions indicated that a return of zero would be used to evaluate the quality of their decisions. Subjects responded to each choice problem separately and were

and were not permitted to return to a previous problem once a response was provided. Each subject was run individually in his or her own office. They were given ample time to respond.

## Results

Table 5 presents the number of times the same gamble in a pair (either GI & GI or GII & GII) was chosen under a positive and negative translation, and the number of times a shift in choice occurred, i.e., from GI to GII or GII to GI, for the 84 subjects for the four pairs of gambles that would be predicted to show reversals.

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Insert Table 5 about here

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Similar to the results obtained in the previous experiments, the most common pattern of choice involved the reversal from GII to GI when gambles were translated by negative amounts. A test of the equality of the correlated proportions associated with shifts in choice again indicated a significant difference ( $\chi^2(1) = 73.33, p < .01$ ). Overall, the proportion of choices of GI under the positive translation was .35, while the proportion of choices of GI under the negative translation was .66.

## 5. RELATION OF RESULTS TO OTHER MODELS

The results of this study, while consistent with the predictions of the Fishburn and Kahneman-Tversky models, indicate that the consistency principle discussed earlier is likely to be violated whenever a translation involves crossing an aspiration level. Furthermore, the violation of this principle is strong enough to lead to choice reversals. In addition, the results are inconsistent with two frequently used formulations of risky choice behavior,



the mean-variance dominance model and utility theory with uniformly concave (risk averse) utility functions.

#### Mean-Variance Dominance

A traditional model of risky choice behavior is one based on mean-variance dominance, a model originally introduced by Markowitz [17] and subsequently applied by many other researchers. Individuals are presumed to choose between risky alternatives by comparing their means and variances, with higher means and lower variances being preferred. Risk aversion of the individual is reflected in the preference for a lower rather than a higher variance.

Since adding or subtracting a constant from both alternatives in a pair will change means by the amount of the constant, but not affect variances, individual preferences based on mean-variance dominance cannot be reversed by the types of translations used in the present experiments. The preference ordering that existed for an individual for any pair of alternatives prior to a translation would remain intact after the translation if the mean-variance dominance model underlies choice behavior. The extensive switching of choices observed in the experiments is therefore inconsistent with the predictions of the mean-variance dominance model. More generally, since additive translations of all outcomes cannot affect the magnitude of any moment computed about the mean, the observed switching of choices provides evidence against the adequacy of any type of mean-moment dominance model. An attempt to explain the switching observed in this study by resorting to moments about the mean of higher-order than the variance will therefore also fail.

## Utility Theory With Concave Utility Functions

Another commonly used model of individual choice behavior is utility theory with a uniformly concave utility function, i.e., a utility function which exhibits risk aversion everywhere. Given the pairs of alternatives used in the experiments of this study, the observed switching of choices is also inconsistent with the existence of uniformly concave utility functions.

Hadar and Russell [8] introduced the concept of second-order stochastic dominance (SSD) of risky alternative X over another risky alternative Y, with SSD occurring when

$$\int_a^r F(x)dx \leq \int_a^r G(y)dy$$

for all values of return  $r$  and with one strict inequality holding for at least one value of  $r$ . In the condition for dominance of X over Y,  $a$  is the lowest possible return from both alternatives and  $F(\cdot)$  and  $G(\cdot)$  are the cumulative probability distributions for alternatives X and Y respectively. This definition of SSD implies that X dominates Y if the area under the cumulative probability distribution for X is less than or equal to the corresponding area under the cumulative probability distribution for Y all values of return, and strictly less for at least one value of return.

For this paper, the important property of SSD, as Hadar and Russell demonstrated, is that dominance of X over Y in the sense of SSD is equivalent to a preference ordering of X over Y when an individual has a uniformly concave utility function. That is, SSD of X over Y is both a necessary and a sufficient condition for a preference of X over Y for all underlying utility functions that are uniformly concave.

All of the pairs of alternatives used in the three experiments, where choice reversals were predicted by the Fishburn and Kahneman-Tversky models, could be ordered by SSD.<sup>6</sup> Since positive and negative translations cannot alter the relative areas under the cumulative probability distributions for a given pair of alternatives, SSD was always retained when both positive and negative translations were employed. Hence, preference orderings would also be retained if utility functions were uniformly concave

Aggregated responses from all experiments for positive and negative translations of gambles are summarized in Table 6. For the three experiments the gambles were redesignated so that GII was always the alternative in the pair that dominated GI in the sense of SSD, for both positive and negative

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Insert Table 6 about here

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translations, and hence would be the preferred alternative for an individual with a strictly concave utility function. Out of the 660 total responses, just 159 (approximately 24%) were consistent with uniform concavity for both positive and negative translations. For the 478 responses that selected GII with the positive translations, 319 of them switched to GI, and hence violated the concavity assumption, when the gambles were translated by an equal negative amount. In contrast, for the 201 responses that chose GII for the negative translations, only 42 switched to GI and violated concavity when the gambles were translated by a positive amount. This differential response to positive and negative translations, in terms of inconsistency with concavity, suggests that concavity is more likely to be violated when alternatives are translated by negative amounts hence bringing the aspiration level into a more influential role in determining choice.

## 6. MODEL OF ASPIRATION LEVEL EFFECTS

As a way of providing a summary of the present results, along with a summary of the ideas and results contained in the literature, the following set of propositions about the effects of aspiration levels on risky choice has been developed. Consider Figure 1 which shows the relationship of two hypothetical gambles, GI and GII, to various levels of aspiration. For ease of exposition, start with the target at level  $t_2$  and consider the proportion of choices of GI denoted  $P(GI)$ , and the proportion of choices of GII denoted  $P(GII)$ .

Proposition 1: If the target is at  $t_2$ , then  $P_{t_2}(GI) < P_{t_2}(GII)$ . Furthermore,  $P_{t_2}(GI)$  will be close to zero. These predictions are based on the dominance relationship suggested by the Fishburn model.

Proposition 2: If the target is at  $t_1$ , then  $P_{t_1}(GI) < P_{t_1}(GII)$ . However,  $P_{t_1}(GI) > P_{t_2}(GI)$  and  $P_{t_1}(GI)$  will increase as  $t_1$  is lowered. The basic idea is that decision makers will pay more attention to maximization of gain when the minimum assured gain is increased. This prediction is consistent with the concept of decreasing risk aversion [10], [13].

Proposition 3: If the target is at  $t_3$ , then either  $P_{t_3}(GI) > P_{t_3}(GII)$  or  $P_{t_3}(GI) < P_{t_3}(GII)$ . However, given steeper utility functions for below target outcomes relative to equal above target outcomes [7], [11], it is likely that  $P_{t_3}(GI) < P_{t_3}(GII)$ .

Proposition 4: If the target is at  $t_4$ , then  $P_{t_4}(GI) > P_{t_4}(GII)$ . This prediction is based on the idea that perceived risk is primarily a function of probability of loss [19] or failure to achieve a target level of return [6].

Proposition 5: If the target is at  $t_5$ , then  $P_{t_5}(GI) > P_{t_5}(GII)$ . However,  $P_{t_5}(GI) < P_{t_4}(GI)$  and  $P_{t_5}(GI)$  will decrease as  $t_5$  is increased. The first part of this proposition is based on the existence of a convex utility function in the loss domain [7], [11]. The second part is based on the idea that a "ruinous loss"

constraint may make minimization of maximum loss important to a choice between gambles as the lowest value of GI approaches the ruinous outcome value. As suggested by Crum, et al. [5] and Kahneman and Tversky, [11] a ruinous loss may lead to a concave segment in the utility function for losses. Figure 2 presents a graphic summary of these predictions. The data from the present study supports the propositions between  $t_2$  and  $t_4$ . In many ways, this model represents a

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Insert Figure 2 about here

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contingent or lexicographic process of risky choice. The assumption is that the probability of failing to reach an aspiration level plays an important screening role in determining choice. In particular, a probability of failure at either 0 or 1 for one alternative and not for another is likely to play the key role in determining preferences. If the probability of failure for both alternatives is between 0 and 1, then the probabilities of the various outcomes of the gambles are likely to be combined or traded off with the values of the outcomes in a fashion consistent with expectation types of models such as expected utility.

The model suggests a decision process similar to one presented in Payne and Braustein [29]. The process suggested was that individuals will often make an initial judgment about whether they are faced with an attractive set of gambles (where the probability of winning exceeds the probability of losing) or an unattractive set (where the probability of losing exceeds the probability of winning) before deciding on the choice rule to be used. Empirical support for that process is presented in Payne [19], Payne and Braustein [20] and Ranyard [24].

Coombs and Avrunin [4] have proposed a general theory of choice behavior that includes a related idea. These authors view choice as a form of conflict resolution. At the individual level, the conflict involves tradeoffs among a set of different and imperfectly correlated goals. Coombs and Avrunin identify three types of conflict situations: approach-avoidance, approach-approach, and avoidance-avoidance. The first situation involves choice options where each option has both good attributes (approach) and bad attributes (avoidance). In an approach-approach situation, each option has only good attributes. In an avoidance-avoidance situation, each option has only bad attributes.

Coombs and Avruin [3] suggest that the latter two situations can be reduced to an approach-avoidance situation and the preference function defined similarly for all three situations. The model offered in this paper, however suggests that the preference function used to choose among gambles is likely to be contingent on whether the risky choice situation is an approach-approach situation ( $t_1$ ), an approach-avoidance situation ( $t_3$ ), or an avoidance-avoidance situation ( $t_5$ ). In particular, for the other two possible situations with equal expected value gambles, a mixed approach-approach and approach-avoidance situation ( $t_2$ ) and an approach-avoidance and avoidance-avoidance situation ( $t_4$ ) will lead to different preference functions.

Although the principles involved in the present model are rather simple, it is clear that the model leads to a more complex predictive problem for decision researchers. For one thing, the model requires the researcher to identify the decision situation as perceived by the decision maker, especially as it relates to an aspiration level. This is likely to be more difficult than assuming a common decision rule such as maximization of expected utility based on a common risk attitude such as risk aversion.

## 7. CONCLUSIONS AND IMPLICATIONS

The present study was motivated by two recent theories of risky choice by Fishburn and Kahneman and Tversky that have placed emphasis on the concept of an aspiration level.<sup>7</sup> The results obtained provide general support for both theories. The relationship of a pair of gambles relative to an assumed level of aspiration was varied through a translation of all outcomes. The results demonstrate that adding or subtracting a constant amount of money for all outcomes in a pair of gambles generally results in a reversal of choices within the pair. Such a finding supports the importance of the concept of a target return or a reference point, or more generally, a level of aspiration, in the analysis of risky choice behavior. Furthermore, the pattern of results suggest that a key determinant of the effect of such translations is whether the size of the translation is sufficient to result in one gamble having outcome values either all above or all below the target, while the alternative gamble has outcome values that are both above and below the target.

The prevailing view about risk attitude in management science research, for both normative and positive models, ignores the aspiration level concept and assumes that decision makers are uniformly risk averse. Results of this paper, in conjunction with other studies cited earlier, indicate that this prevailing assumption is inadequate from a descriptive viewpoint.

The consensus emerging from empirical studies is that a more descriptive set of assumptions about risk attitudes is one where (1) the utility (or value) function is defined in terms of initial wealth and changes in wealth, rather than terminal wealth, where (2) changes in wealth are evaluated relative to an aspiration level or target return, with gains (losses) being defined as a change in wealth above (below) the target return, where (3) risk

preference, when ruinous loss is not a concern, is a mixture of risk seeking for losses and risk aversion for gains, and where (4) ruinous loss considerations lead to lexicographic choice behavior that screens alternatives out from further consideration. This characterization, which is discussed in detail by Kahneman and Tversky [11] and Libby and Fishburn [15], has not yet been explored in the context of management science models.

For positive models, which tend to be judged by the accuracy of their aggregate predictions rather than accuracy of underlying assumptions, it is unclear whether these more descriptive assumptions about risk attitude will lead to models with improved aggregate predictions while maintaining similar levels of parsimony, analytical tractability, and the requisite second-order conditions. Only future research efforts will be able to resolve these important issues. A strong case for examining the impact of increased descriptive accuracy of assumptions in positive models is provided by Simon [27].

For normative models, which are designed to aid in the decision process, the issue of descriptive reality of assumptions can be put in clearer focus. Normative models are more likely to be evaluated by the accuracy of their assumptions, particularly assumptions that relate to risk attitudes of the decision maker for whom the model is designed. Inadequate assumptions in this circumstance may lead to rejection of a model, by the decision maker no matter how elegant or how easy it is to deal with analytically, unless it can be demonstrated that model results are insensitive to the challenged assumptions. In addition, trying to change the risk attitude of a decision maker to match the standard assumption of uniform risk aversion, an approach suggested by Keeney and Raiffa [13, p. 200], is highly questionable. Incorporation of more realistic assumptions about risk attitudes in normative models offers a more promising prospect for research, with a potential of improving



the track record of implementation of normative management science models. This is true even though analytical tractability will undoubtedly be sacrificed for approximate solutions. The need to engage in such research is aptly summarized by Simon [27, p. 498]:

"...decision makers can satisfice either by finding optimum solutions for a simplified world, or by finding satisfactory solutions for a more realistic world. Neither approach dominates the other..."

FIGURE 1

Basic Structure of GI and GII and Translations

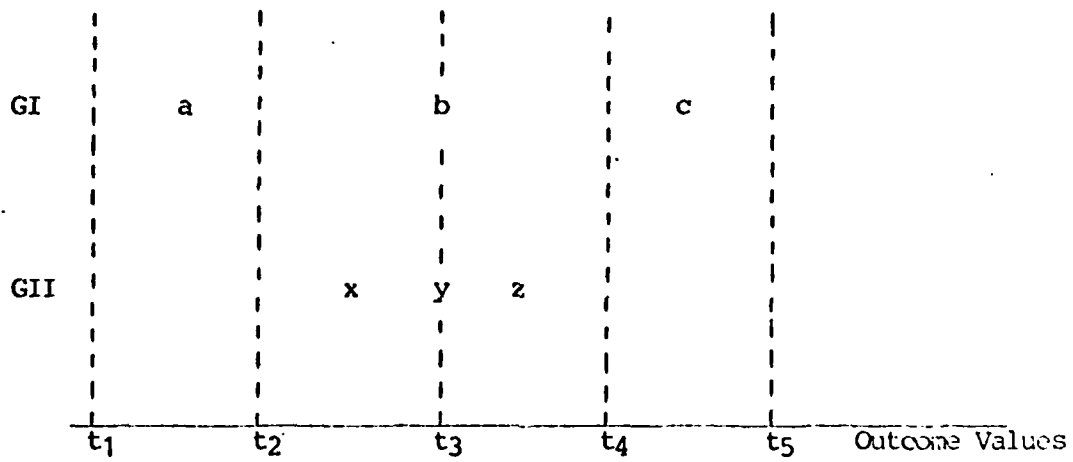


FIGURE 2  
Summary of Predicted Choice  
Proportions

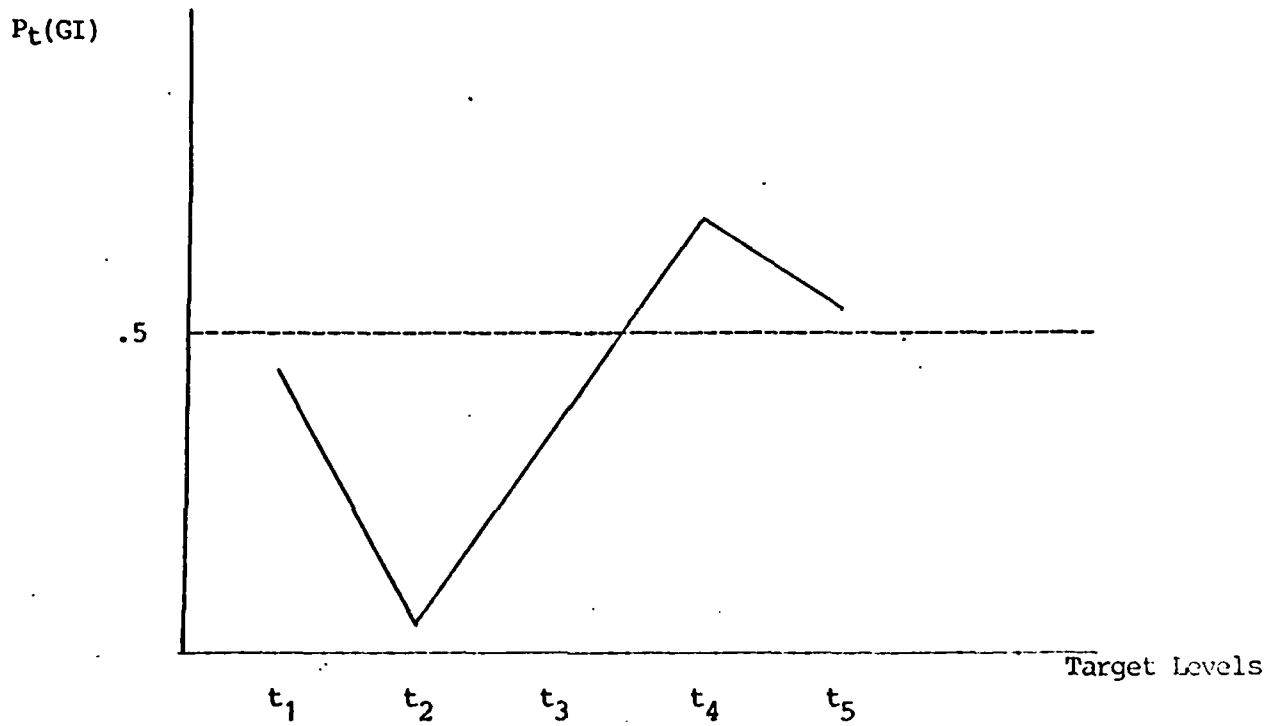


TABLE 1  
Gambles for Experiment 1

<u>Set 1</u>	<u>Set 2</u>
Gamble	Gamble
A = (44, .5; 0, .1; -55, .4)	A = (36, .5; 0, .2; -60, .3)
B = (10, .3; 0, .5; -15, .2)	B = (8, .4; 0, .4; -16, .2)
X = (55, .4; 0, .1; -44, .5)	X = (60, .3; 0, .2; -36, .5)
Y = (15, .2; 0, .5; -10, .3)	Y = (16, .2; 0, .4; -8, .4)
<u>Set 3</u>	<u>Set 4</u>
Gamble	Gamble
A' = (74, .5; 30, .1; -25, .4)	A' = (62, .5; 26, .2; -34, .3)
B' = (40, .3; 30, .5; 15, .2)	B' = (34, .4; 26, .4; 10, .2)
X' = (85, .4; 30, .1; 14, .5)	X' = (86, .3; 26, .2; -10, .5)
Y' = (45, .2; 30, .5; 20, .3)	Y' = (42, .2; 26, .4; 18, .4)
<u>Set 5</u>	<u>Set 6</u>
Gamble	Gamble
A'' = (14, .5; -30, .1; -85, .4)	A'' = (10, .4; -26, .2; -86, .3)
B'' = (-20, .3; -30, .5; -45, .2)	B'' = (-18, .4; -26, .4; -42, .2)
X'' = (25, .4; -30, .1; -74, .5)	X'' = (34, .3; -26, .2; -62, .5)
Y'' = (-15, .2; -30, .5; -40, .3)	Y'' = (-10, .2; -26, .4; -34, .4)

TABLE 2  
Choice Proportions for Experiment 1

Gambles		Sets 1,3,5			Sets 2,4,6		
Pair	\$30	\$0	-\$30	\$26	\$0	-\$26	
A,B	.17	.37	.67	.17	.43	.67	
A,Y	.17	.37	.67	.23	.33	.67	
X,B	.23	.40	.60	.30	.40	.57	
X,Y	.30	.33	.67	.27	.57	.83	
A,X	.30	.43	.20	.57	.57	.50	
B,Y	.50	.63	.67	.80	.47	.63	

<sup>1</sup>Proportion of the 30 subjects choosing the first gamble in each pair.

TABLE 3  
Pattern of Choices for Translated  
Pairs of Gambles in Experiment 1

		Negative Translation	
		GI	GII
Positive Translation	GI	40	16
	GII	120	64

Entries indicate to number of choices of GI and GII for the  
indicated combinations of positive and negative translations.

TABLE 4  
 Gambles and Choice Data  
 from Experiment 2

<u>Problem 1</u>	<u>Problem 2</u>
GI=(30, .6; 0, .1; -60, .3)	GI=(12, .5; 0, .2; -20, .3)
<u>32</u> <sup>1</sup>	<u>27</u>
GII=(8, .5; 0, .3; -20, .2)	GII=(30, .4; 0, .4; -60, .2)
<u>10</u>	<u>15</u>
<u>Problem 3</u>	<u>Problem 4</u>
GI'=(55, .6; 25, .1; -35, .3)	GI'=(37, .5; 25, .2; 5, .3)
<u>6</u>	<u>38</u>
GII'=(33, .5, 25, .3; 5, .2)	GII'=(55, .4; 25, .4; -35, .2)
<u>36</u>	<u>4</u>
<u>Problem 5</u>	<u>Problem 6</u>
GI"=(5, .6; -25, .1; -85, .3)	GI"=(-13, .5; -25, .2; -45, .3)
<u>36</u>	<u>5</u>
GII"=(-17, .5; -25, .3; -45, .2)	GII"=(5, .4; -25, .4; -85, .2)
<u>6</u>	<u>37</u>

<sup>1</sup>Number of subjects choosing the gamble listed above.

TABLE 5

Pattern of Choices for  
Translated Pairs of Gambles in  
Experiment 3

		Negative Translation	
		GI	GII
Position	GI	90	26
	GII	136	84

Entries indicate the number of choices of GI and GII for the indicated combinations of positive and negative translations



TABLE 6

Pattern of Choices for Translated Pairs  
of Gambles in All Three Experiments

		Negative Translation	
		GI	GII
Positive Translation	GI	140	42
	GII	319	159

Entries indicate the number of choices of GI and GII  
for the indicated combinations of positive and negative  
translations.

REFERENCES

1. Atkinson, J. W. & Raynor, J. O., (Eds.), Motivation and Achievement, Washington, D. C.: V.H. Winston, 1974.
2. Conrath, David W., "From Statistical Decision Theory to Practice: Some Problems with the Transition," Management Science, 1973, 19, 873-883.
3. Coombs, C. H. & Arvunin, G. S., "A Theorem on Single-peaked Preference Functions in One Dimension," Journal of Mathematical Psychology, 1977, 16, 261-266.
4. \_\_\_\_\_, "Single-peaked Functions and the Theory of Preference," Psychological Review, 1977, 84, 216-230.
5. Crum, R., Laughhunn, D., & Payne, J. W., "Risk Preference: Empirical Evidence and Its Implications for Capital Budgeting," in F.G.J. Derkinderen & R. L. Crum (Eds.), Financing Issues in Corporate Project Selection, Boston: Martinus Nyhoff, in press.
6. Fishburn, P.C., "Mean-risk Analysis with Risk Associated with Below-target Returns," The American Economic Review, 1977, 67, 116-126.
7. \_\_\_\_\_ & Kochenberger, G. A., "Two-piece Von Neumann-Morgenstern Utility Functions," Decision Sciences, 1979, 10, 503-518.
8. Hadar, J. & Russell, W. R., "Rules for Ordering Uncertain Prospects," American Economic Review, 1969, 59, 25-34.
9. Hershey, J. C. & Schoemaker, P.J.H., "An Examination of Prospect Theory's Reflection Hypothesis," unpublished manuscript, 1979.
10. Holloway, C. A., Decision Making under Uncertainty: Models and Choices, Englewood Cliffs, N. J.: Prentice-Hall, 1979.
11. Kahneman, D. & Tversky, A., "Prospect Theory: An Analysis of Decisions under Risk," Econometrica, 1979, 47, 262-291.
12. Karmarkar, U. S., "Subjectively Weighted Utility: A Descriptive Extension of the Expected Utility Model," Organizational Behavior and Human Performance, 1978, 21, 61-72.

13. Keeney, R. L. & Raiffa, H., Decisions with Multiple Objectives: Preferences and Value Tradeoffs, New York: John Wiley, 1976.
14. Krantz, D. H., Luce, R. D., Suppes, P. & Tversky, A., Foundations of Measurement, New York: Academic Press, 1971.
15. Libby, R. & Fishburn, P., "Behavioral Models of Risk Taking in Business Decisions: A Survey and Evaluation," Journal of Accounting Research, 1977, 15, 272-292.
16. Mao, J.C.T., "Survey of Capital Budgeting: Theory and Practice," Journal of Finance, 1970, 25, 349-360.
17. Markowitz, H., Portfolio Selection, New York: John Wiley and Sons, 1959.
18. Messinney, W.H., "Aspiration Levels and Utility Theory," in G. Fisk (Ed.), The Psychology of Management Decision, Lund, Sweden: CSK Gleerup Publishers, 1967.
19. Payne, J. W., "Relation of Perceived Risk to Preferences Among Gambles," Journal of Experimental Psychology: Human Perception and Performance, 1975, 1, 86-94.
20.                & Braumstein, M. L., "Preferences Among Gambles with Equal Underlying Distributions," Journal of Experimental Psychology, 1971, 87, 13-18.
21.                & Carroll, J. S., "Exploring Pre-decisional Behavior: An Alternative Approach to Decision Research," Organizational Behavior and Human Performance, 1978, 22, 17-44.
22. Petty, J. W. II & Scott, D. F., "Capital Budgeting Practices in Large American Firms: A Retrospective Analysis and Update," in P.G.J. Derkinderen & R.L. Crum (Eds.), Financing Issues in Corporate Project Selection, Boston: Martinus Nijhoff, in press.
23. Pfanzagl, J., "A General Theory of Measurement--Applications to Utility," Naval Research Logistics Quarterly, 1959, 6, 283-294.
24. Ranyard, R. H., "Elimination by Aspects as a Decision Rule for Risky Choices," Acta Psychologica, 1976, 40, 299-310.

1. Siegel, S., "Level of Aspiration and Decision Making," Psychological Review, 1957, 64, 253-262.
2. Simon, H. A., "A Behavioral Model of Rational Choice," Quarterly Journal of Economics, 1955, 69, 99-118.
3. \_\_\_\_\_, "Rational Decision Making in Business Organizations," American Economic Review, 1979, 69, 493-513.
4. Williams, C. A., "Attitudes Toward Speculative Risk as an Indication of Attitudes Toward Pure Risks," Journal of Risk and Insurance, 1966, 33, 577-586.

FOOTNOTES

- <sup>1</sup> This view of outcomes as being gains or losses is an alternative to the view of assessing outcomes in terms of final asset position, as is the case in most expected utility analyses.
- <sup>2</sup> Empirical support for the assumption that the value function is steeper for losses than for equivalent gains can be found in Fishburn and Kochenberger [7].
- <sup>3</sup> Hershey and Schoemaker [9] have raised some questions about the strength of the evidence presented by Kahneman and Tversky on the reflection effect. They note that the data presented by Kahneman and Tversky does not make clear how much individual reflectivity occurred, i.e., within subjects. They also present some data of their own that is mixed with respect to the reflection effect, additional research seems warranted.
- <sup>4</sup> This statement presumes that the value function, denoted  $v(\cdot)$ , is indexed so that  $v(t_3)=0$ . In this case,  $v(x)<0$  for  $x<t_3$  where  $x$  denotes return.
- <sup>5</sup> Complete protocols for the ten subjects may be obtained from the first author.
- <sup>6</sup> Pairs for which choice reversals are not predicted by the Fishburn and Kahneman-Tversky models, and for which SSD fails to hold, are (A,X) and (B,Y) in experiment 1 and the related choice pairings in experiment 3.
- <sup>7</sup> We wish to thank John S. Carroll and Hillel Einhorn for their comments on an earlier draft of this paper. In addition, we wish to thank the reviewers for their extensive and helpful comments and Charles Bond and Robert Johnson for their assistance in running experiments 1 and 2. This research was supported in part by a grant from the Engineering Psychology Programs, Office of Naval Research.

## APPENDIX

### Protocols for Positive and Negative Translations of Gamble Pair A,B from Experiment 1

GI : (\$74,.5;\$30,.1;-\$25,.4)

GI : (\$14,.5;-\$30,.1;-\$85,.4)

GII: (\$40,.3;\$30,.5; \$15,.2)

GII: (-\$20,.3;-\$30,.5;-\$45,.2)

Subject: A

- 1: O.K., ah, good chance of winning and losing in number two (GI).
- 2: Ah, another guaranteed win in the first (GII).
- 3: Oh, that \$74, I mean it's good,
- 4 but the chances are just as high that I'll lose 25.
- 5: And, it looks like I'll probably get 30 or 40 in number one.
- 6: So, I'm going to go with number one.

Choice: GII

- 1: Oh my, another one like this.
- 2: Ah, I've got high losses,
- 3: with the only possible chance of winning.
- 4: Umm, looks like in the first one (GII) I'm going to lose 20 or 30 bucks.
- 5: Second one (GI) I could lose 85.
- 6: Could win 14
- 7: Uh, 14 is just you know-it's not enough to offset that 85.
- 8: Just really, I'm going to have to go with number one.

Choice: GII

Subject: B

- 1: In this case, gamble one (GI) has one negative outcome
- 2: and gamble two has none.
- 3: On the 50% chance of a gain along with a 10% chance of a gain for gamble one makes it enticing to look at the \$74
- 4: but the 40% chance of losses again overcomes the fact that I'd rather have steady returns.
- 5: So therefore I pick gamble two
- 6: and have a chance of lesser rate of return

Choice: GII

- 1: O.K., in this gamble-gamble one (GI) is two negatives
- 2: and gamble two (GII) is three negatives.
- 3: Again the first gamble has one positive outcome
- 4: with the chance of 50%
- 5: whereas gamble two you're admitting you're going to lose.
- 6: In this case I'd feel it.
- 7: It would be worth risking gamble one to try for that gain even through the lose is 85.

Choice: GI

Subject: C

- 1: O.K., in this one I have a 50% chance of winning \$74. (GI)
- 2: 40% of losing 25.
- 3: Second one (GII) I win it all,
- 4: but then I can only win up to \$50.
- 5: Umm, this one I think I would go to the first one
- 6: cause I'd win more money.
- 7: And, although I'd lose some.
- 8: I'd win some.
- 9: The difference is for greater than the amount won.

Choice: GI

- 1: O.K., in this one, (GI) uh, 40% chance of losing \$85.
- 2: But, then I have a 00% chance of winning 14.
- 3: The second one (GII) I have ... Oh, I could lose 45,30, or 20 dollars.
- 4: But, I have a greater chance of losing the \$30 in the 2nd one than losing.
- 5: But, I have the same option,
- 6: I might lose the \$85.
- 7: I think I'll pick the second one
- 8: cause I don't want to lose \$85.

Choice:..GII

Subject: D

- 1: O.K., the same situation as it was.
- 2: In here in gamble one (GII) lose money.
- 3: Where the amounts won compared to that in gamble two (GI) are not as high.
- 4: Ah, looking at the 25 dollars lost.
- 5: Uh, that would be lost in gamble two -
- 6: probability 40%.
- 7: O.K., amount
- 8: There's a 50% chance of winning \$74.
- 9: and a 10% chance of winning less than that.
- 10: Uh, I'm not .. I'd like to win some money.
- 11: And, since I've got 50% chance of even,
- 12: and less than even odds, and less than even odds losing the 25.
- 13: That's going to be my choice.

Choice: GI

- 1: Here I see I've got a 50% chance of winning choice two (GI).
- 2: No chance of winning choice one (GII).
- 3: Although there is a larger loss risk in choice two.
- 4: Still you only got a 40% chance of losing
- 5: You lose the most in 50% chance of winning.
- 6: So, two is the one.

Choice: GI

---

Subject: E

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- 1: I pick ... in this choice  
I would pick number one  
(GII).
- 2: because I wouldn't want  
to take the 40% chance  
of losing.

Choice: GII

- 1: In this situation I can't  
help but lose money.
- 2: 50% is just .. but in the  
first gamble (GI) although  
I can possibly lose \$85.
- 3: There is a chance of loss,
- 4: but also gain money.
- 5: My chance is 50%.
- 6: I pick the first one.

Choice: GI

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Subject: F

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- 1: O.K., in number one (GI)  
I have a 50% chance of  
gaining \$74
- 2: and in number two (GII) I  
have a 50% chance of gain-  
ing \$30.
- 3: In number one I have a 40%  
chance of loss.
- 4: And in number two I have  
no chance of loss.
- 5: Think I'm going to go with  
number two
- 6: just based on the fact that  
the number one has a 40%  
chance of \$25 loss
- 7: and in number two I have -  
there's no possibility of  
loss whatsoever.

Choice: GII

- 1: O.K., let's see, in number  
one (GII) - I have a 50%  
chance of losing 30
- 2: and in number two (GI) I have  
a 50% chance of gaining \$14.
- 3: In number two I have a 40%  
chance of losing \$85.
- 4: And, in number one I have no  
chance to gain anything.
- 5: And, in number two I have  
great - a great possibility  
that I will lose \$85.
- 6: However, in number two there's  
also a 50% chance of gaining
- 7: and there's no chance of gain  
in number one.
- 8: So, I think I'll go with  
number two.

Choice: GI

---

Subject: G

---

- 1: O.K., in outcome one 50%  
chance I'd win \$30.
- 2: 30% chance I'd
- 3: O.K., I'm automatically  
going to win money in number  
one (GII).
- 4: but in outcome two there's  
a 40% chance I'd lose \$25.
- 5: I think I would take the  
safe outcome one
- 6: cause 40% is a pretty high  
percentage to lose \$25.

Choice: GII

- 1: Problem A outcome one (GI)  
40% chance of losing \$85.
- 2: That sounds tough --
- 3: don't like that.
- 4: Um that's a 50% chance I  
lose money
- 5: and a 50% chance I'll gain  
money.
- 6: Whereas there's a 100% chance  
I'll lose money in problem two  
(GII).
- 7: Most of the percentage lies



- 8: where I'd have 50% chance of losing \$30.
- 9: Ummm - well I don't like the looks of losing \$85.
- 10: I think I'd go with outcome one
- 11: because the least amount of money I'd have to give in outcome two is \$20.
- 12: And that .. \$20 is still a lot of money.
- 13: I rather take my chances and try and least gain some money
- 14: so I take outcome one.

Choice: GI

---

Subject: H

- 1: I am looking at problem number one.
- 2: A in both experiments.
- 3: And there is a 50% chance of winning \$30 in experiment two (GI).
- 4: However, in problem B in experiment one (GI) there is a 50% chance of winning \$74
- 5: which offsets the problem of 40% probability in C of losing \$25.
- 6: Yet by comparison in experiment two you win money in any of the three probabilities.
- 7: Therefore I would choose number two.

Choice: GII

- 
- 1: O.K., looking again at gamble two (GI) probability A.
  - 2: There is a 50% chance of money.
  - 3: Whereas in gamble one (GI) there's no chance of winning money.
  - 4: I pick two.

Choice: GI

---

Subject: I

- 
- 1: O.K., number one (GII) has all winning.
  - 2: uh, let's see, 20% chance of winning \$15.
  - 3: 30% chance of winning the most.
  - 4: And, a 50% chance of winning \$30.
  - 5: Number two (GI) there's a 40% chance of losing \$25
  - 6: which would pretty much,

- 
- 1: Number one (GII), a 20% chance of losing \$40.
  - 2: A 50% chance of losing \$30.
  - 3: A 30% chance of losing
  - 4: Number two (GI), a 40% chance of losing \$85.
  - 5: 10% chance of losing \$30.
  - 6: And, a 50% chance of winning.

- prelude picking it.
- 7: And, a 50% chance of winning \$74
  - 8: which would be pretty great.
  - 9: But, I would still say that the possible loss - 40% is possible loss.
  - 10: I'm not going to pick that one.
  - 11: I'm going to pick number one.

Choice: GII

- 7: But, you don't win that much.
- 8: And, if you lose there's that 40% chance of losing \$85
- 9: which is quite a bit.
- 10: Number one is an automatic loss probability.
- 11: Probably being around 35-50 dollars.
- 12: In number two you do have a 50% chance of winning
- 13: based on that, I'm going to go with number two.

Choice: GI

---

Subject: J

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- 1: O.K., I'm looking at gamble one (GII) and two (GI).
- 2: Probability A and amount A. Comparing the amounts
- 3: - the same.
- 4: Although, the probability for gamble one is much better.
- 5: So, it's not bad, \$30.
- 6: So I move to B and compare them.
- 7: But, in gamble one B is not too good a chance.
- 8: It's not worth it.
- 9: It's not worth too much.
- 10: Whereas, gamble two B is good chance of losing something.
- 11: So, I move to C in gamble two.
- 12: It is very good. 50% chance of making \$74.
- 13: Whereas gamble one, 30% chance of making \$40.
- 14: So, I think I'd go with one. Simply because you can't lose.
- 15: There's a pretty good chance of losing too.

Choice: GII

- 1: I'm looking at gamble one (GI) and two (GII) probability A.
- 2: They are both losers.
- 3: Gamble one is an even bigger loser.
- 4: So, I look at B, and they are both losers too,
- 5: same amount.
- 6: Probability for gamble one is much lower.
- 7: The probability is higher in gamble two.
- 8: The amounts was still a little bit lower.
- 9: Look at C. Gamble one
- 10: - there's 1/2 chance of winning a little bit.
- 11: Whereas C in gamble two you're going to lose a
- 12: Well, gamble two you don't ... you're going to lose no matter what in gamble two.
- 13: Gamble one is a big chance of losing a lot.
- 14: So, I'd go with gamble two.

Choice: GII

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